

## Morphological revision of phytal red-stripe *Eudactylopus fasciatus* Sewell, 1940 (Crustacea, Copepoda, Harpacticoida) from Bangaram Island, Lakshadweep, India

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### ABSTRACT

Specimens of the harpacticoid copepod *Eudactylopus fasciatus* Sewell, 1940 were found in plankton samples taken from Lakshadweep, India. In this study, *E. fasciatus* is redescribed on several additional distinct morphological characters along with the original description dating back to 1940 (Sewell, 1940). The most important features of *E. fasciatus* from Bangaram Island are the external coloration pattern with eight longitudinal bands, additional numbers of setae on the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 7<sup>th</sup> segments of the A1, and the modified saber-shaped sexually dimorphic second endopod segment of the male P2 with a bud-like structure. The illustrated redescription and a taxonomic key for the identification of all the species of the genus *Eudactylopus* are also provided.

### KEYWORDS

Indian Ocean, phytal harpacticoid, redescription, taxonomy, taxonomic key

### INTRODUCTION

The true phytal harpacticoid copepods of the family Thalestridae Sars, 1905 are mostly meiobenthic and inhabit the blades of seagrass and surrounding sediments (Hicks and Coull, 1983) and macroalgae (Boxshall and Halsey, 2004). The systematic position and the species composition of the family have been controversial subjects over several decades (Lang, 1936;

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SUBMITTED 26 July 2021

ACCEPTED 29 March 2022

PUBLISHED 28 November 2022

DOI 10.1590/2358-2936e2022029



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Nauplius, 30: e2022029

1944; Hicks, 1988; Willen, 2000). According to Willen (2000), the family comprises 17 genera in two subfamilies: the Eudactylopusinae Willen, 2000 and the Thalestrinae Sars, 1905. The genus *Eudactylopus* was originally described by A. Scott (1909) with *Dactylopus latipes* (T. Scott, 1893) as the type species, based on several morphological characters such as body shape, rostral appearance, number of abdominal somites, 2<sup>nd</sup> endopod segment of the antennae, and setal formulae of the swimming legs. Claus (1863; 1866) described *Thalestris robusta* Claus, 1863 from Nice, France, that was later assigned to the genus *Eudactylopus* A. Scott, 1909 as *Eudactylopus robustus* (Claus, 1863) by Lang (1936). Brady (1905) reported *T. robusta* from tidal pools at Cullercoats, United Kingdom, but later Wilson (1925) changed the specific name to *Thalestris valida* Wilson, 1925. Brian (1923) reported *Parathalestris clausi spectabilis* Brian, 1923 from the Mediterranean Sea but later Brian (1928) raised it to the species rank as *Parathalestris spectabilis*, which was subsequently assigned to the genus *Eudactylopus* as *E. spectabilis*. Monard (1928) reported this species from the Mediterranean Sea and described it under the genus *Eudactylopus*. Brian (1928) also established the genus *Plesiothalestris* Brian, 1928 to accommodate *Plesiothalestris opima* Brian, 1928 (f. *major* and f. *minor*), but the genus was changed to *Eudactylopus* by Sewell (1940). In 1940, Sewell described *Eudactylopus fasciatus* Sewell, 1940, and *Eudactylopus striatus* Sewell, 1940 from the Indian Ocean. These species were considered as subspecies and junior synonyms of *E. robustus* by Noodt (1955). The species *Eudactylopus krusadensis* Krishnaswamy, 1950 was ignored by taxonomic studies due to the vague description and incomplete drawings. In 1995 Chang and Song redescribed two species of genus *Eudactylopus*, *E. spectabilis* and *E. andrewi* from the coast of Korean waters. Recently, *E. yokjidoensis* has been described from the coast of South Korea, a species closely resembling *E. andrewi* and *E. spectabilis*. Identification of current Lakshadweep specimens, based on Sewell (1940) and comparison with the description and illustrations of *E. fasciatus* from Nicobar, confirm the Lakshadweep specimens to be *E. fasciatus* (see Sewell, 1940). De Grave (2001) reported that the two islands of Lakshadweep and Nicobar have high diversity, but they have different

geomorphological features (Malik *et al.*, 2006; Wagle and Kunte, 1999). As a result, the low-lying coral island of Lakshadweep has a larger surface area, more diversified habitats, and is geographically closer to the high-diversity sections of Nicobar. *Eudactylopus fasciatus* can be differentiated from other species of the genus by the presence of a characteristic cuticular vertical band pattern all over the body. The description of these characteristic features was illustrated by Sewell (1940) in the original description, but not mentioned in detail and so a redescription of the species is provided herein. *Eudactylopus striatus* also possesses conspicuous red stripes all over the body, but they differ in being curved. The genus *Eudactylopus* includes 13 species: *E. robustus* (Claus, 1863), *E. latipes* (Scott T., 1893), *E. opimia* (Brian, 1928), *E. spectabilis* (Brian, 1923), *E. anomala* (Sewell, 1940), *E. fasciatus* (Sewell, 1940), *E. andrewi andrewi* (Sewell, 1940), *E. striatus* (Sewell, 1940), *E. australis* (Nicholls, 1941), *E. atlanticus* (Vervoort, 1964), *E. krusadensis* (Krishnaswamy, 1952), *E. lucayosi* (Geddes, 1969), *E. yokjidoensis* (Cho, Wi and Suh, 2018).

In the present study, we complement the original description of *E. fasciatus* with a new description based on material collected recently from Bangaram lagoon, Lakshadweep, India, including novel traits which were found to be exclusive to this species. Thus, the aim of this study is to better define the morphological characters of *E. fasciatus*. An identification key to the females of *E. fasciatus* species is also provided.

## MATERIALS AND METHODS

Plankton samples were collected during the winter-monsoon of March 2015 from Bangaram Island, Lakshadweep Sea, at 3 selected stations (S1, S2, and S3). S1 is a coral area with algal turf protected with live corals; S2 is an inner lagoon covered with macro-algae; S3, a boat channel, is a highly disturbed environment that undergoes frequent dredging for navigational purposes. The samples were collected at 3 m depth using a hand net of mesh size 253  $\mu\text{m}$  (Cordell, 2007) to avoid entangling and disturbances to the corals (Fig. 1). All the collected samples were then rinsed into airtight sample bottles and preserved in 4 % buffered formaldehyde prepared with filtered seawater. Harpacticoid copepods were sorted, dissected,

and mounted using a stereomicroscope. Dissected appendages were examined using a compound microscope (Olympus and Leica). Drawings were made with the aid of a drawing tube attached to a brightfield compound microscope (LynxLM 52-1704) of 40–1000X magnifications. Detailed taxonomic identification was done with the help of standard keys and literature (Sewell, 1929; Nicholls, 1942; Lang, 1948; 1965; Wells and Rao, 1987; Huys and Boxshall, 1991; Huys *et al.*, 1996; Boxshall and Hasley, 2004; Wells, 2007). Total body length was measured from the anterior margin of the rostrum to the posterior margin of the caudal rami. The descriptive terminology is adopted from Huys and Boxshall (1991), and Huys *et al.* (1996). Measurements were recorded with a CAT-CAM CC300 camera. The dissected samples were incorporated into the copepod collection of the Department of Marine Biology, Microbiology and Biochemistry; School of Marine Sciences, Cochin University of Science and Technology (MBM/DBT/15/20).

The following abbreviations are used in the text: A1, first antennae; A2, second antennae; ae,

aesthetasc; C IV, copepodid 4th stage; enp, endopod; exp, exopod; benp, baseopod; enp-1–enp-3, first to third endopodal segments; exp-1–exp-3, first to third exopodal segments; P1–P5, first to fifth swimming legs; R, rostrum; Ur, urosome.

## SYSTEMATICS

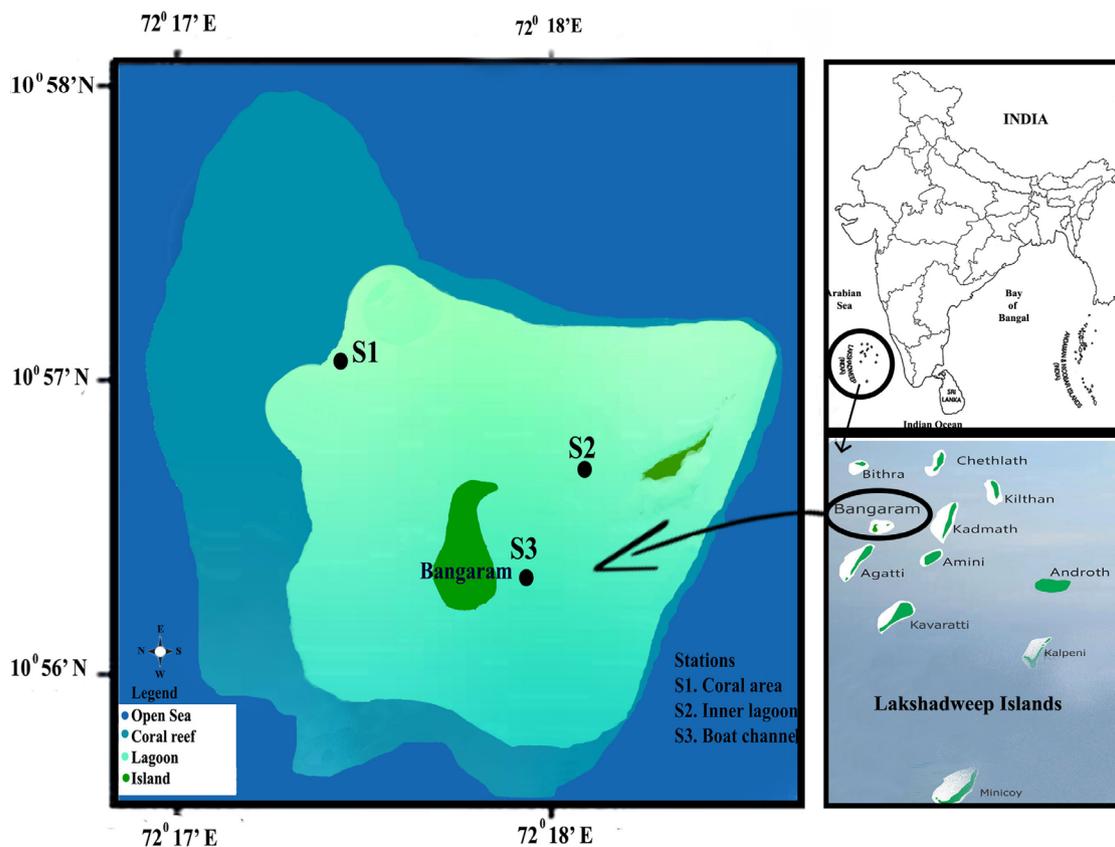
### Family Thalestridae G. O. Sars, 1905

### Genus *Eudactylopus* A. Scott, 1909

### *Eudactylopus fasciatus* Sewell, 1940

*Sampling locality.* Bangaram Lagoon, Lakshadweep

*Material examined.* Holotype: Female, India, Kerala, Lakshadweep, Bangaram (10°56'27.38"N 72°17'29.02"E). Specimens were dissected and mounted (voucher no. MBM/DBT/15). Male specimens were dissected and mounted on 4 slides (voucher no. MBM/DBT/21) from Bangaram Island Lakshadweep.



**Figure 1.** Map showing the sampling stations on Bangaram Island (10°56'27.38"N 72°17'29.02"E), Lakshadweep, Arabian Sea.

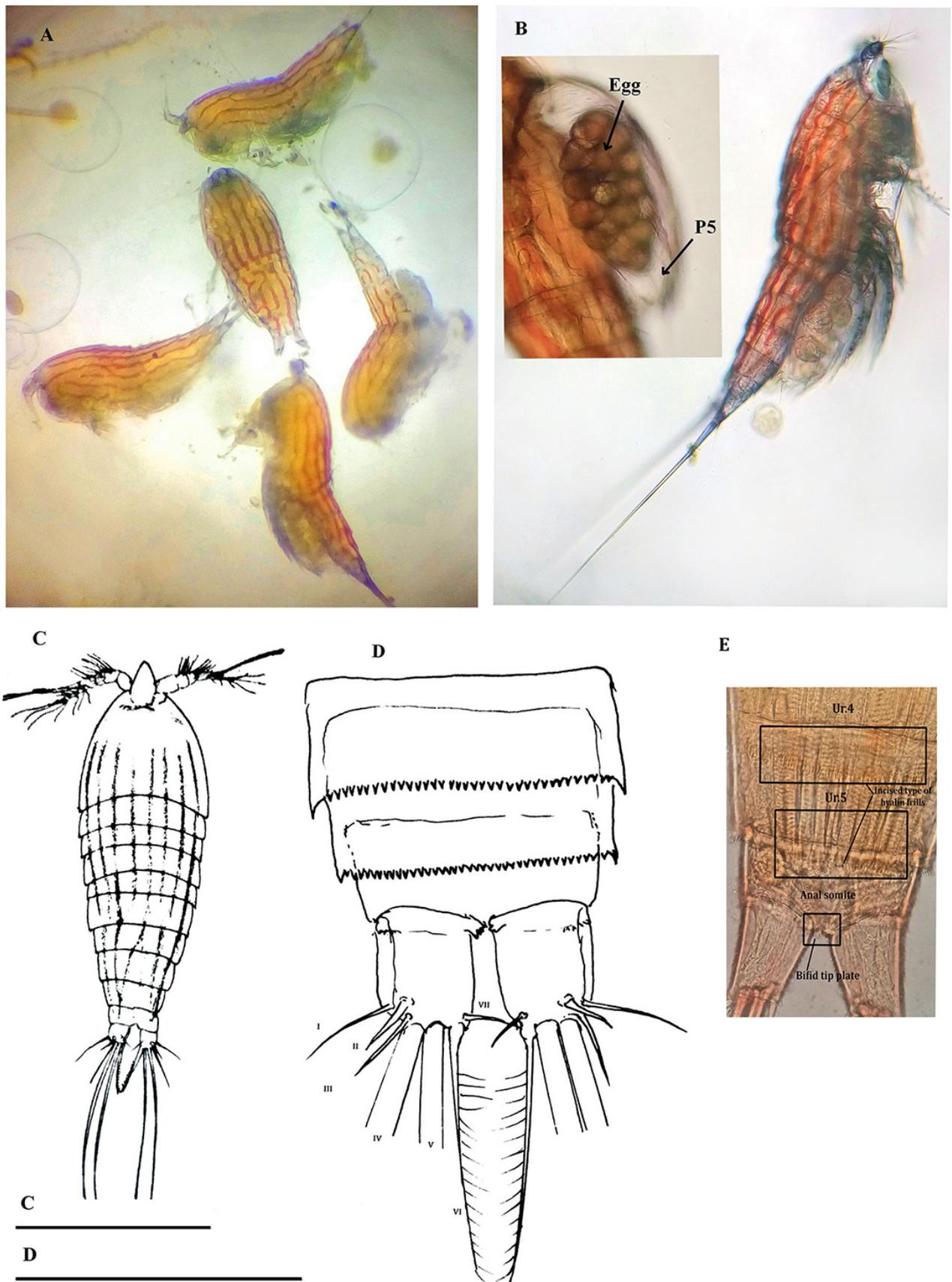
*Redescription of female.* Total body length 1.164 mm, measured from anterior margin of rostrum to posterior margin of caudal rami. Largest width measured at posterior margin of cephalic shield, 0.451 mm. Body stout and fusiform (Fig. 2A, B, C). Rostrum prominent, triangular, slightly curved downwards, rounded at its tip. Prosome comprising cephalothorax with completely fused first pedigerous somite and 3 free pedigerous somites. All somites with an incised type of hyaline frill except fifth pedigerous somite (Fig. 2E). Caudal rami cylindrical, slightly longer than broad, with 6 elements inserted distally. The outer distal edge of 6 ramus showing slight prolongation. Seta I bare, seta II bare and shortest, seta III longer than seta I and II, seta IV and V thickened and long, seta VI bulbous basally and with setules along the inner margin, and seta VII with setules at base and arising from inner dorsal surface. (Figs. 2D, 8G). Dorsal surface of cephalic shield with 8 longitudinal colored bands of which 2 left and 2 right (1, 2, 7, and 8<sup>th</sup>, see Fig. 8A) being considered lateral bands. Dorsal bands 3, 4, 5, and 6 reaching mid-dorsal margin of P5 bearing somite. Five bands continuing downwards onto first urosomite (P5 bearing somite). Rostrum triangular, linguiform reaching beyond length of first antennular segment. Urosome 5-segmented, comprising P5 bearing somite, genital and first abdominal somites fused to form genital double somite and 3 abdominal somites, respectively. Each abdominal somite 1, 2, and 3 with incised type of hyaline frill and anal somite bearing pair of bifid-tipped plates.

Antennule (Fig. 3A) 9-segmented, about as long as cephalothorax. First segment largest bearing an inner longitudinal row of spinules and 1 short seta. Second segment with 11 setae. Third segment with 1 seta in posterior margin and 4 setae on outer distal margin. Fourth segment with 2 setae on outer distal margin, long slender aesthetasc fused basally to 1 apical seta. Fifth segment with 1 outer distal seta. Sixth segment with 3 setae on outer distal margin. Seventh and eighth segments with 1 apical and 1 inner setae. Ninth segment with 4 setae and 1 aesthetasc.

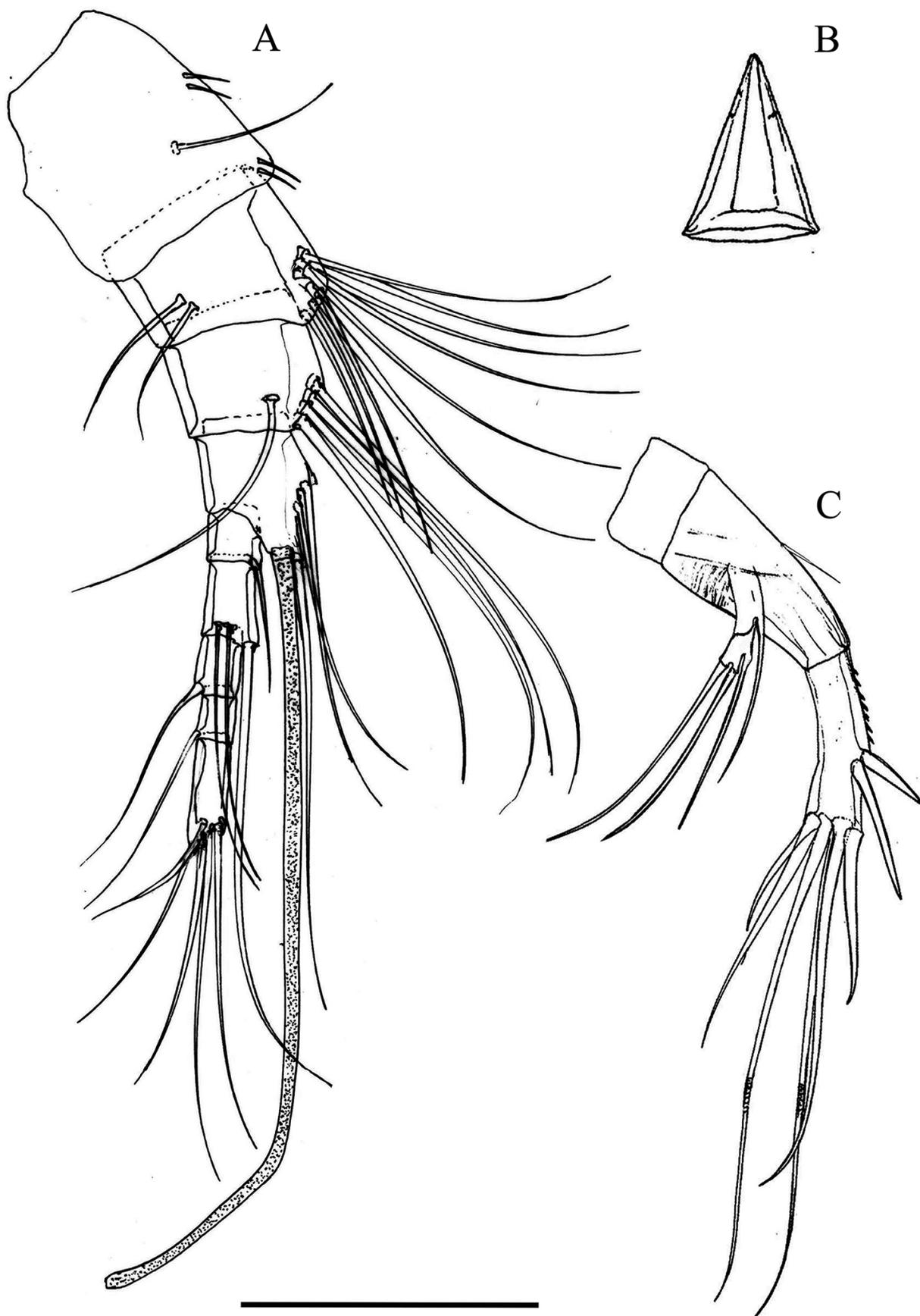
Armature formula: 1-1/2-11/3-5/4-3+1(Ae)/5-1/6-3/7-2/8-2/9-4+1(Ae).

Antenna (Fig. 3C) with coxa, allobasis and free endopodal segment. Coxa small, unornamented. Allobasis (basis and first endopodal segment fused) with 1 exopodal seta on distal third and ornamented with posterior row of minute spinules. Exp-2 segmented, exp-1 longer than exp-2, exp-1 with 1 subapical seta, and exp-2 with 1 subapical and 2 apical setae. Free endopodal segment with 2 inner lateral spines, 2 inner distal spines, 2 geniculate distal setae, 1 outer distal seta, and 1 short outer seta. Mouthparts well developed. Labrum (Fig. 4A) sclerotized, numerous hairs on its posterior margin. Mandible (Fig. 4B) with coxa and short basis fused with coxa. Gnathobase with strong chitinized teeth. Cutting edge with 4 blunt teeth with slender spinule dorsally. Palp 2-segmented, 1 segmented exopod (fused to basis basally) and endopod. Basis with 2 setae. Exopod with 2 setae on outer distal corner of coxa-basis, endopod with 6 setae. Maxillule (Fig. 4C) arthrite of pre-coxa with 7 strong spines along distal margin and claw-like spine on apical margin. Coxa elongated, 3 apical setae on maxillular coxa. Maxilla (Fig. 4D) pre-coxa and coxa fused, outer margin with small spinules. Syncoxa armed with 3 endites. Proximal endite with 2 bipinnate spines; middle with 1 bipinnate seta and spine, distal endite with 2 bipinnate spines. Basal complex with basis drawn into strong claw with 2 small setae near base. Maxilliped (Fig. 4E) prehensile, subchelate, 3-segmented, composed of syncoxa with 3 spinulose setae on inner distal margin and 2 rows of spinules on proximal and distal margins. Enp shorter than basis bearing 1 seta; enp first segment with spinular row on inner margin, distal segment forming a strong claw.

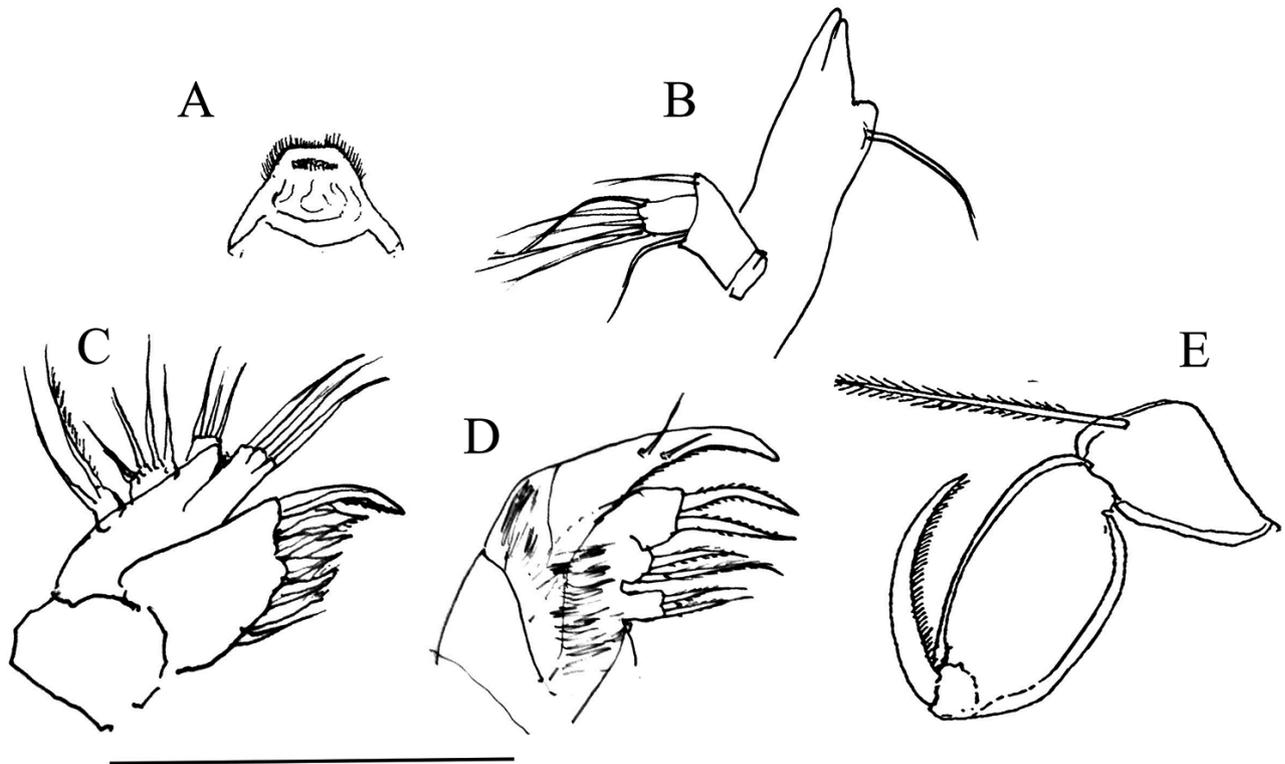
P1 (Figs. 5A, 8A) transversely elongate intercoxal sclerite. Coxa with 1 anterior row of outer spinules. Basis with 1 transverse median row of spinules close to inner margin, with additional spinules at base of basal armature and between rami; basal armature consisting of 1 strong inner and outer spine. Exopod 3-segmented, shorter than endopod. Exopod 1 with 1 robust outer spine, some outer and some distal spinules; exopod 2 longest with 3 inner spinules proximally, with 1 subdistal inner seta and 1 outer median spine; exopod 3 small, with 3 outer spines and 1 serrated seta.



**Figure 2.** *Eudactylopus fasciatus* Sewell, 1940, female. A–C, Habitus, dorsal view; D–E, anal somite and caudal rami, dorsal. Scale bars: 100  $\mu$ m.



**Figure 3.** *Eudactylopus fasciatus* Sewell, 1940, female. **A**, Antennule, ventral view; **B**, rostrum; **C**, antenna, latero-dorsal view. Scale bar: 100  $\mu$ m.



**Figure 4.** *Eudactylopus fasciatus* Sewell, 1940, female. **A**, Labrum; **B**, mandible; **C**, maxillule; **D**, maxilla; **E**, maxilliped. Scale bar: 100  $\mu$ m.

Endopod 2-segmented; endopod 1 elongate, as long as exopod, with 1 long inner seta; enp 2 small, with 2 claws of different lengths, and 1 tiny seta.

P2–P4 with large intercoxal sclerite and well developed precoxa. Exopod and endopod 3-segmented. P2 (Figs. 5B, 8B) basis with 1 strong outer spine; with spinular rows on anterior surface. Exopod 1 with triangular outer distal protuberance with rows of outer spinules, and with 1 outer spine and 1 bipinnate subdistal inner seta; exopod 2 shorter than exopod 1, with triangular inner and outer distal protuberances with some outer spinules and armed with 1 outer spine and 1 bipinnate subdistal inner seta; exopod 3 with 3 outer spines, 1 long apical outer spine, 1 apical inner seta, and 2 bipinnate inner setae. Endopod 1 with triangular inner and outer distal protuberance with some outer spinules and armed with 1 long inner bipinnate seta; endopod 2 with 2 long bipinnate inner setae; endopod 3 with 1 outer spine, 2 apical and 2 inner setae.

P3 (Figs. 6A, 8C) similar to P2, except for basis with 1 thin seta.

P4 (Figs. 6B, 8D) basis with thin outer seta as in P3. Exopod 1 and exopod 2 with triangular outer protuberance distally, with outer and inner spinules, with 1 outer spine and 1 subdistal inner seta, exopod 3 with 3 outer spines, 1 long apical outer spine, 1 apical bipinnate inner seta, and 3 long inner, subdistal bipinnate setae. Endopod 1 with inner and outer triangular distal protuberances, endopod 2 wider than enp-1, with inner and outer triangular distal protuberance with 1 long bipinnate inner seta; endopod 3 with 1 small outer spine, 2 apical and 2 inner bipinnate setae. P5 (Figs. 2B, 7A, 8E) well developed; baso-endopod and exopod separated, baso-endopod larger than exopod, with outer seta arising from long setophore. Endopodal lobe larger than exopod, with 4 distal setae, with small spinule between setae and subdistally along outer margin. Exopod with 6 setae on the distal margin with different lengths. Outer and distal margins armed with fine setules.

P6 (Figs. 7B, 8F) unsegmented with small protuberance bearing 3 setae.

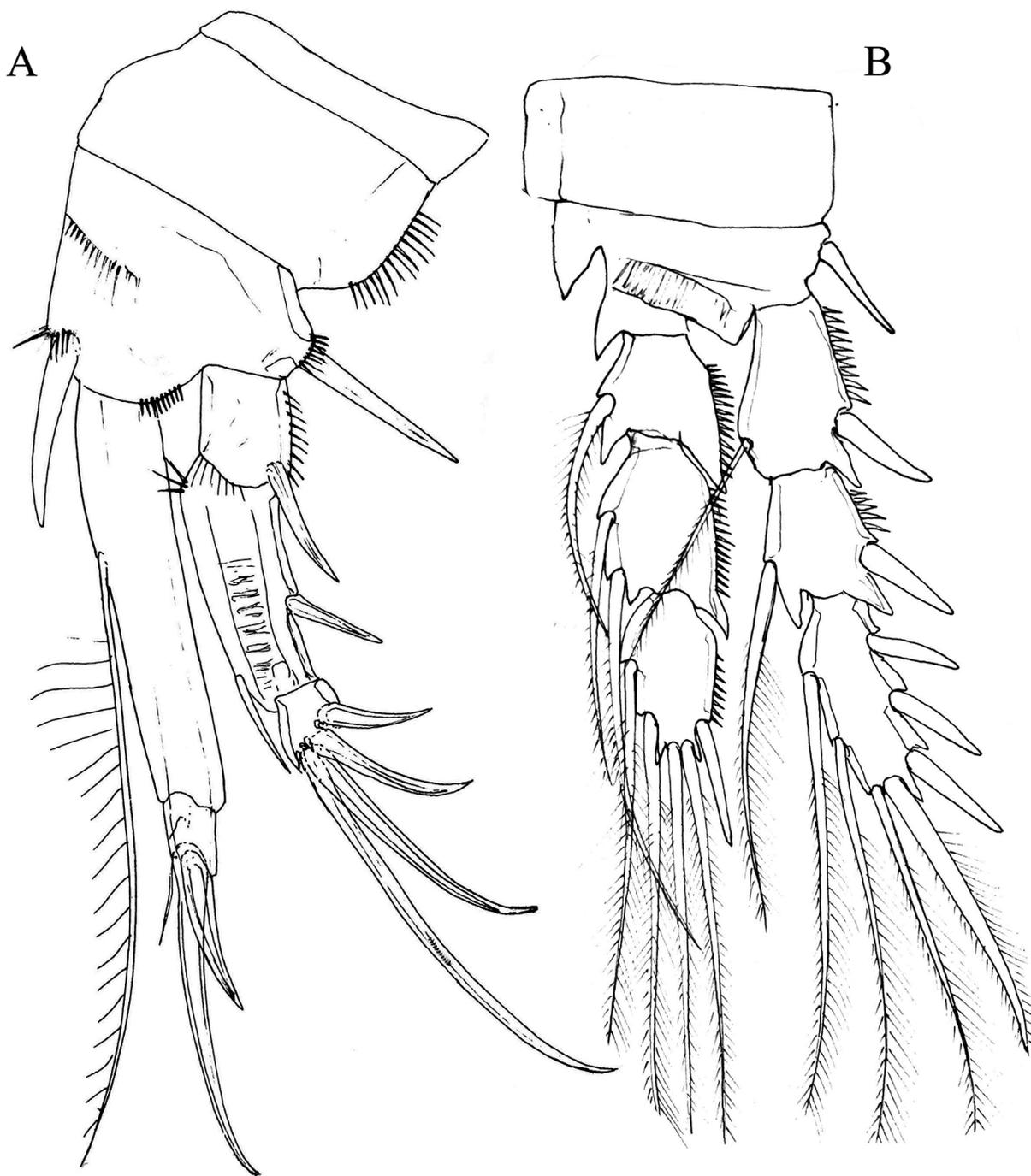
Armature formula P1–P4 as in [Tab. 1](#).

**Table 1.** Female *Eudactylopus fasciatus* Sewell, 1940. Armature formula of swimming legs. P2–P4, swimming legs (pereopods).

| Swimming legs | Exopod             | Endopod         |
|---------------|--------------------|-----------------|
| P2            | I-1; I-1; III.II.2 | 0-1; 0-2; I.2.2 |
| P3            | I-1; I-1; III.II.2 | 0-1; 0-2; I.2.3 |
| P4            | I-1; I-1; III.II.2 | 0-0; 0-1; I.2.2 |

Egg sac ([Fig. 2B](#)): eggs lies between pair of P5 which looks like a brood pouch protecting the eggs.

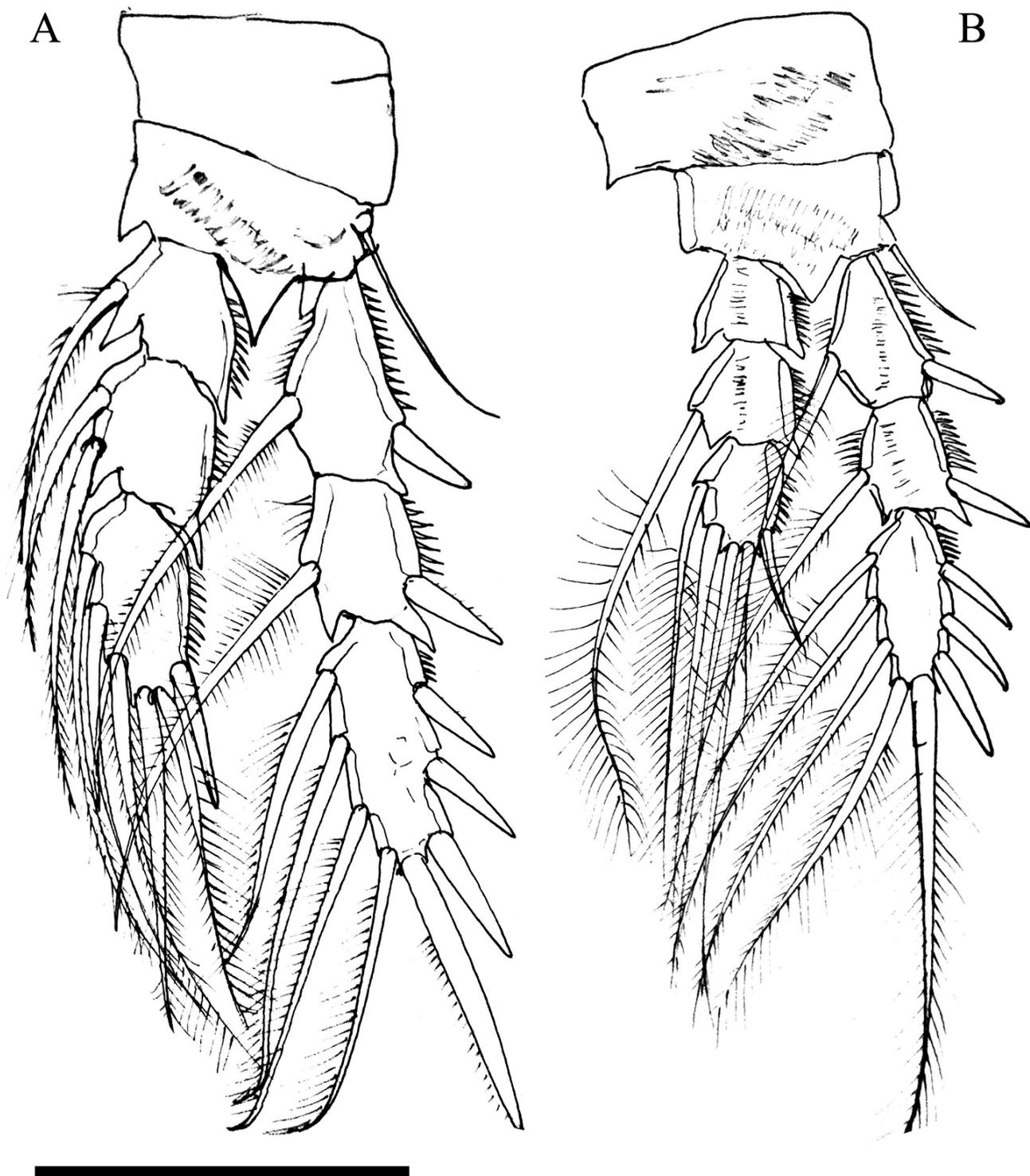
*Description of the male.* Total body length 1.096 mm (n = 6) measured from anterior margin of rostrum to posterior margin of caudal rami. The salient features of P2 and P5 are as follows. P2 modified. P2 exopod



**Figure 5.** *Eudactylopus fasciatus* Sewell, 1940, female. A, P1, anterior; B, P2, anterior. Scale bar: 100  $\mu$ m.

3-segmented; endopod 2-segmented; exopod 1 with strong outer spine and single inner seta; exopod 2 shortest, with 1 strong outer spine and 1 inner seta; exopod 3 composed of 3 strong outer spines, 1 long outer spine and 3 inner setae increasing in size distally.

P2 endopod 1 bearing single marginal spine on inner border. Endopod 2 leg completely modified. Second and third segments fused (Figs. 7C, 9A). Longitudinal rows of minute spinules along proximal half of outer margin and armed with 3 strong inner setae, 1 inner



**Figure 6.** *Eudactylopus fasciatus* Sewell, 1940, female (A) P3, anterior ; (B) P4, anterior . Scale bar 100  $\mu$ m.

apical seta, 1 apophysis (an internal projection of the seta, often spoon-like), and 1 modified element. The copepodite IV of *E. fasciatus* male are represented in Fig. 9B–H. Copepodite IV having 2, 3, and 4 legs with exopod and endopod. Exopod and endopod being 2-segmented and later 3-segmented.

P5 (Fig 7D) smaller than those of female. Inner expansion of basal segment very short, with 3 unequal (1 inner, 1 distal elongated, 1 outer minute) setae. Exp with 5 setae (2 outer spiniform elements, 1 outer subdistal and 1 inner subdistal slender seta, and 1 apical strong seta).

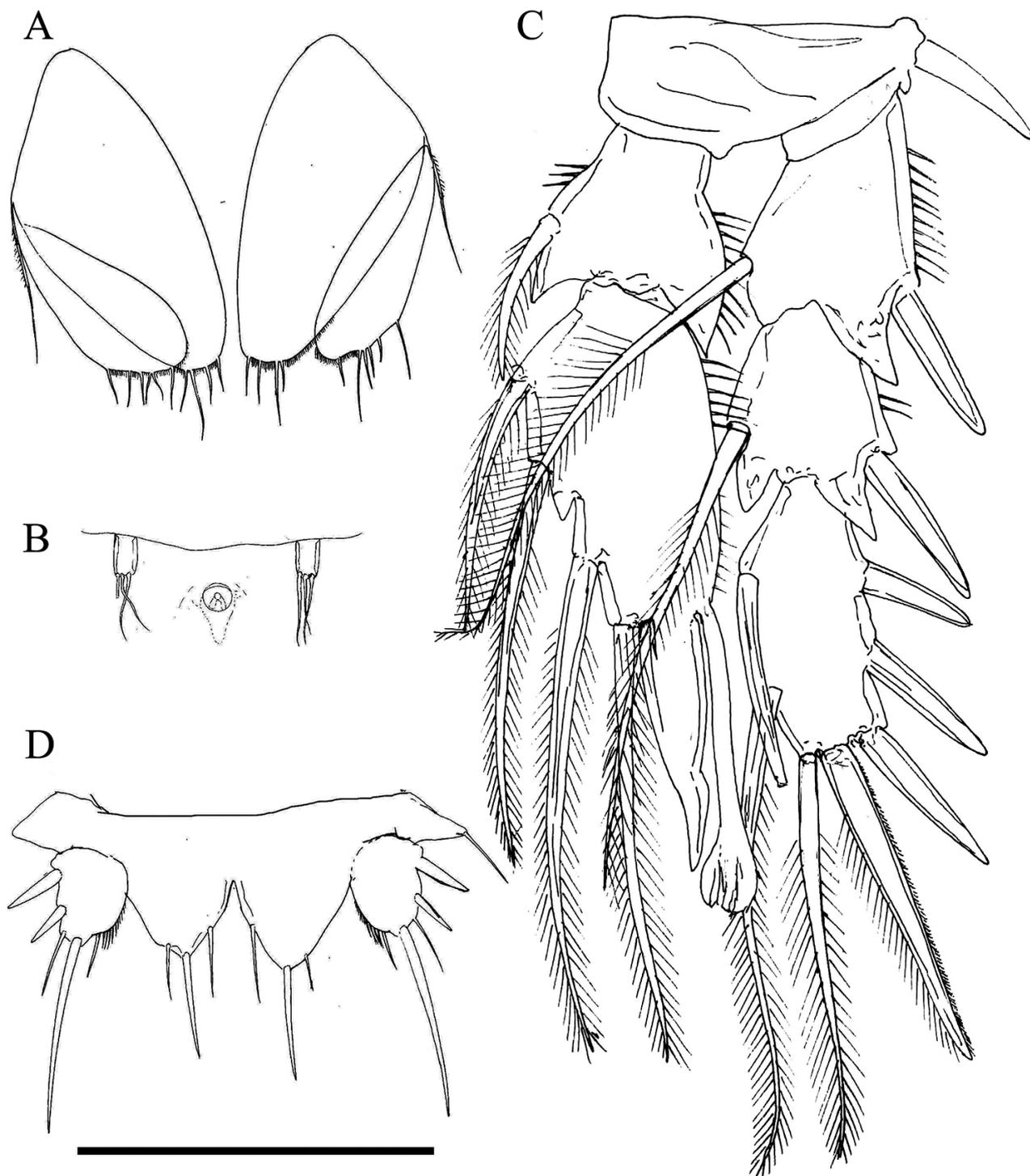
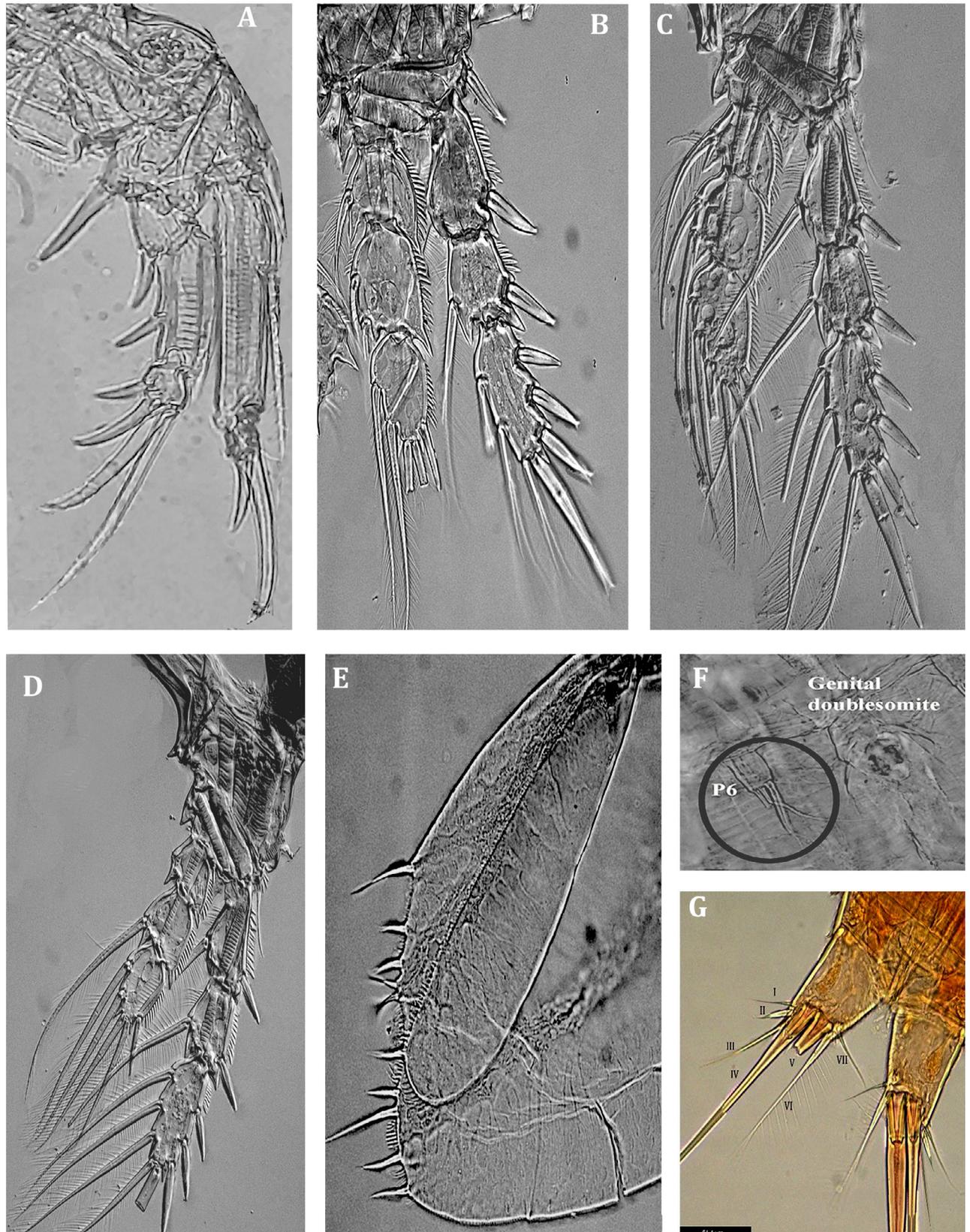


Figure 7. *Eudactylopus fasciatus* Sewell, 1940, female. A, P5; B, P6. Male, C, P2; D, P5. Scale bar: 100 µm.



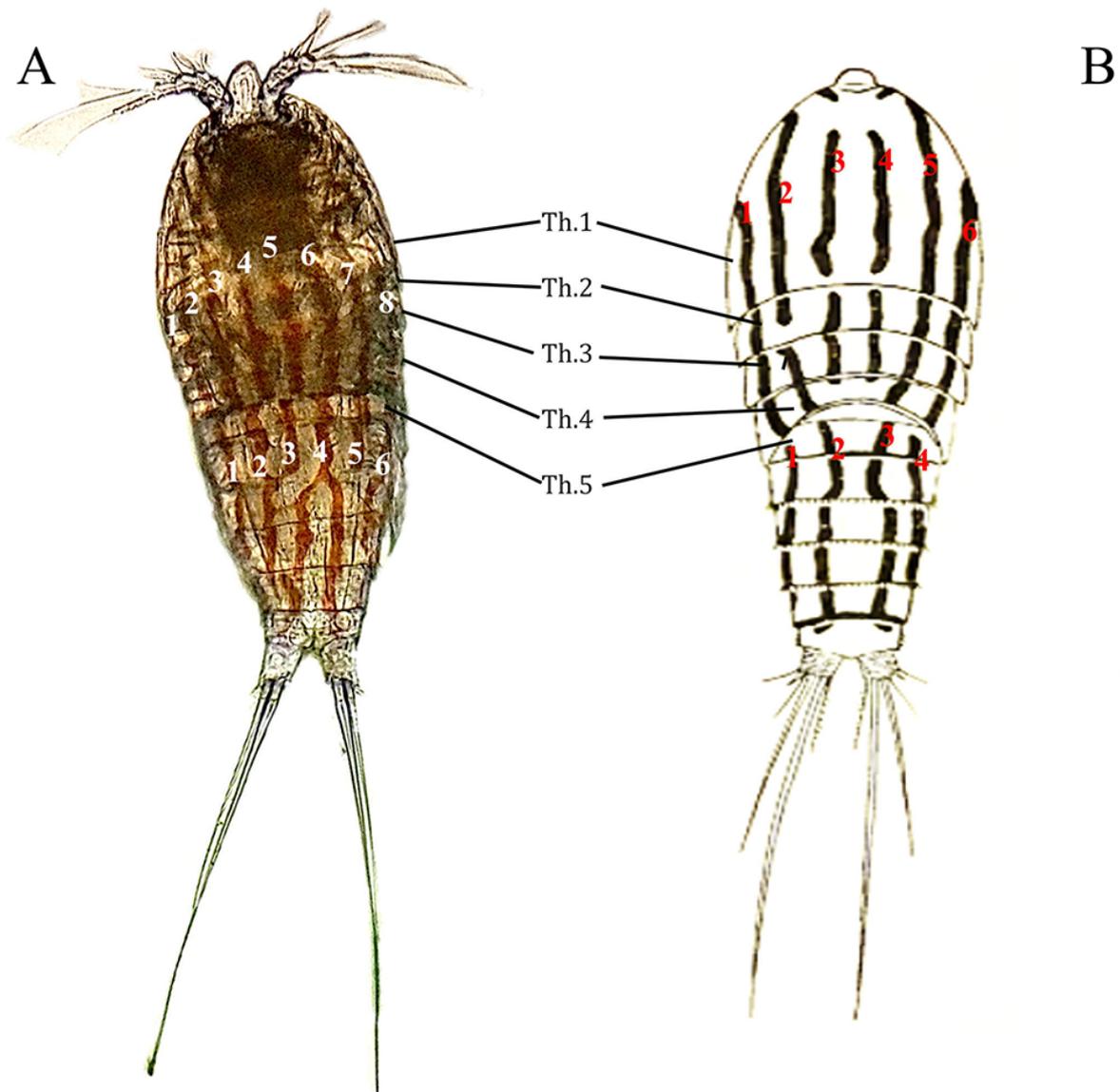
**Figure 8.** *Eudactylopus fasciatus* Sewell, 1940, female. A, P1; B, P2; C, P3; D, P4; E, P5; F, P6; G, caudal rami. Scale bars: 100 μm.

**Figure 9.** *Eudactylopus fasciatus* Sewell, 1940, male. **A**, P2; **B**, copepodid stages (C IV) - A1; **C**, C IV - Ur; **D**, C IV - P1; **E**, C IV-P2; **F**, C IV - P3; **G**, C IV - P4; **H**, C IV - P5. Scale bars: 100  $\mu$ m.

## DISCUSSION

*Eudactylopus fasciatus* is characterized from other species due to its beautiful coloration. Some remarkable variation has been observed in several morphological characters of the populations of *E. fasciatus* collected from Bangaram Island compared to Sewell's (1940) original description (material from the weed areas of Nankauri harbour, Nicobar Island and Addu Atoll, Maldive Archipelago). The cephalothorax of *E. fasciatus* from Bangaram Island possessed 8 bands (6 bands are present in the Nicobar Island specimen) that are longitudinally aligned. Bands 1, 2, 7, and 8 extend

until the caudal ramus area in the Bangaram specimen (bands 1, 2, 5, and 6 extend to the caudal ramus in the Nicobar Island specimen). The central 3, 4, 5, and 6 bands end at the posterior margin of the IV<sup>th</sup> thoracic somite in the Bangaram specimen (the central pair ends at the posterior margin of IV<sup>th</sup> thoracic somite in the Nicobar Island specimen). The remaining six bands in the Bangaram specimen (four bands in Sewell's material in the Nicobar Island specimen) continue across the V<sup>th</sup> thoracic segment and then down to the abdomen, as far as the last urosomite (Fig. 10). This species is morphologically different from *E. striatus* but similar in the color pattern.



**Figure 10.** *Eudactylopus fasciatus* Sewell, 1940. **A**, Bangaram specimen (Bangaram Islands, Lakshadweep, southwestern Arabian Sea, Indian Ocean); **B**, Sewell's (1940) specimen (Andaman and Nicobar islands, Nancowry (= Mankauri) Harbour, northeastern Indian ocean). Th.1- Th.5 (Thoracic segments 1-5).

The antennule first segment has one seta in Bangaram specimens (*vs.* no seta in the Nicobar specimen), second segment has 11 setae in Bangaram specimens (*vs.* five setae in the Nicobar specimen), third segment has eight setae in Bangaram specimens (*vs.* four setae in the Nicobar specimen), seventh segment has two setae in Bangaram specimens (*vs.* one seta in the Nicobar specimen) and the eighth segment has two setae in Bangaram specimens (*vs.* one seta in the Nicobar specimen). The setal elements on 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup>, and 9<sup>th</sup> antennular segments were similar to the original description. The second endopodal segment of P2 and P3 have two inner setae each whereas P4 possesses a single seta in accordance with the original description. The P5 is droplet- or tear-shaped. P5 of

*E. fasciatus* has a very narrow articulation area and a broad, rounded terminal portion as in Sewell's original description of the species.

We collected only a few males. In the specimens from Nicobar, the second and third endopodal segments of P2 are fused together, and two stout modified spines (one terminal plain seta and one subterminal seta on the outer side with a spatulate apex) arise from the distal part of the outer end. In male specimens from Bangaram, Lakshadweep the enp-2 and enp-3 are completely fused. The shape of the modified leg P2 was sabre-like with two modified thick spines, one at the distal end and the second as a bud-like structure at the distal outer angle (*vs.* two pointed thickened spines at the distal outer angle in Sewell's material).

#### Key to the species of *Eudactylopus*.

- |    |   |  |
|----|---|--|
| 1a | Rostrum triangular with round apex .....  | 2a   |
| 1b | Rostrum sharply triangular, free end with pointed apex .....                              | 8b   |
| 2a | A1 7-segmented, aesthetasc on 3 <sup>rd</sup> and 4 <sup>th</sup> segment in female ..... | 6b   |
| 2b | A1 7-segmented, 2 aesthetascs on 4 <sup>th</sup> segment in female .....                  | 9b   |
| 3a | A1 8-segmented, aesthetasc on 3 <sup>rd</sup> and 4 <sup>th</sup> in male .....           | <i>E. anomala</i> Sewell, 1940               |
| 3b | A1 9-segmented, aesthetasc on 4 <sup>th</sup> only .....                                  | 5b   |
| 4a | A1 9-segmented aesthetasc on 3 <sup>rd</sup> and 4 <sup>th</sup> in male .....            | 5a   |
| 4b | A1 9-segmented aesthetasc on 4 <sup>th</sup> and 5 <sup>th</sup> in male .....            | 7a   |
| 5a | P2 enp extending to proximal apex of exp3 in males .....                                  | <i>E. striatus</i> Sewell, 1940              |
| 5b | P2 end extends to middle of Exp-3 at most in males .....                                  | <i>E. fasciatus</i> Sewell, 1940             |
| 6a | P5 droplet-shaped; inner seta of P5 exp short .....                                       | <i>E. opimia</i> (Brian, 1928)               |
| 6b | P5 square-shaped; inner seta of P5 exp is long, comb-like .....                           | 9a   |
| 7a | P5 droplet-shaped; inner seta of P5 exp long and bipinnate .....                          | <i>E. spectabilis</i> (Brian, 1923)          |
| 7b | P5 droplet-shaped; inner seta of P5 exp long .....  | <i>E. robustus</i> (Claus, 1863)             |
| 8a | P5 oblong-shaped; inner seta of P5 exp is short .....                                     | <i>E. lucayosi</i> (Geddes, 1969)            |
| 8b | P5 wide flap-like structure .....   | <i>E. latipes</i> (T. Scott, 1893)           |
| 9a | Basendopod exp of P5 fused .....  | <i>E. andrewi</i> Sewell, 1940               |
| 9b | Basendopod and exp of P5 separated .....  | <i>E. yokjidoensis</i> Cho, Wi and Suh, 2018 |

#### ACKNOWLEDGEMENTS

We express our sincere gratitude to Prof. Paulo Henrique Costa Corgosinho for his valuable comments and providing useful taxonomic literature during the development of this manuscript. We are thankful to the Department of Biotechnology, Govt. of India, the Department of Marine Biology, Microbiology and Biochemistry, Cochin University of Science and

Technology, Department of Science and Technology, Lakshadweep for providing necessary facilities, and support. The first author also expresses thanks to Dr. Sanu V.F. for his valuable support.

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